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Strengths of Geo Polymer Concrete by Adding Metakaoline

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Abstract:*Based on the results obtained from this study ,the following Conclusions seems to be valid. The increase in percentage replacement of Fly Ash with Metakaoline from 0% to 10.00% causes increase in Slump value up to 5% and beyond that slump is decreased. This shows workability is reducing as percentage of Metakaoline increased beyond 5%. Hence, 5% replacement of Fly ash with Metakaoline is suitable from workability point of view. The increase in percentage replacement of Fly ash with Metakaoline from 0% to 5% causes increase in compressive strength of concrete from 17.6MPa to 22.6MPa. Further increase in percentage replacement of Fly ash with Metakaoline from 5% to 10% causes decrease in the compressive strength from 22.6MPa to 18.7MPa. Hence, 5.00% replacement of Fly Ash with Metakaoline is advisable from compressive strength point of view .The increase in percentage replacement of Fly ash with Metakaoline from 0% to 5% causes increase in Split Tensile strength of concrete from 3.72MPa to 4.68MPa. Further increase in percentage replacement of Fly ash with Metakaoline from 5% to 10% causes decrease in the split Tensile strength from 4.68MPa to 3.94MPa. Hence, 5.00% replacement of Fly Ash with Metakaoline is advisable from Split Tensile strength point of view. The increase in percentage replacement of Fly ash with Metakaoline from 0% to 5% causes increase in flexural strength of concrete from 3.0 MPa to 3.36 MPa. Further increase in percentage replacement of Fly ash with Metakaoline from 5% to 10% causes decrease in the flexural strength from 3.36MPa to 3.2MPa.Hence 5.00% replacement of fly ash with Metakaoline is advisable from flexural strength point of view.Finally,it can conclude keeping in view of the workability ,compressive strength ,split tensile strength and flexural strength in mind,5% replacement of fly ash with Metakaolin is recommended for use in GEO POLYMER CONCRETE (GPC).*

Index Terms: *Geo polymer,Alkaline Solution, Metakaoline Fly ash.*

I. INTRODUCTION

1.1 GENERAL

Concrete, artificial engineering material made from a mixture of Portland cement, water, fine and coarse aggregates and a small amount of air. It is the most widely used construction material in the world. Concrete is the only major building material that can be delivered to the job site in a plastic state. This unique quality makes concrete desirable as a building material because it can be molded to virtually to any form or a shape. Concrete provides wide latitude in surface textures and colors and can be used to construct a wide variety of structures such as highways and streets, bridges, dams, large buildings, airport runways, irrigation structure, break waters, piers and docks, sidewalks, soils and farm building homes and even barges and ship. Other desirable qualities of concrete as a building material are its strength, economy and durability. Depending on the mixture of materials used, concrete will support, in compression, 700 or more kg/sq cm, (10,000 or more 1b/sq cm). The tensile strength of concrete is much lower when compared to compressive strength of concrete, but by using properly designed steel reinforcing, the structural members can be made that are as strong as in compression. The durability of concrete is evidenced by the fact that concrete columns built by the Egyptians more than 3600 years ago are still standing.

Concrete is the premier construction material around the world and is most widely used in all types of construction works, including infrastructure, low and high-rise buildings, and domestic developments. It is a man-made product, essentially consisting of a mixture of cement, aggregates, water and admixture(s). Inert granular materials such as sand, crushed stone or gravel form the major part of the aggregate. These materials are blended in required proportions according to the strength parameter and Grade of concrete.

1.2 DEVELOPMENT OF GEO POLYMER CONCRETE: A MODERN INNOVATION

From the awareness of reduction in the cement content in concrete many countries tried different combinations of replacing cement with pozzoloniac materials. These are some of the countries which took initiative for the production of GPC.

Table 1: Worldwide status of GPC

Country	Production yield in Tons	% of World Production
UK	21565700	34.9
Australia	15667600	25.4
India	10148000	16.4

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Brazil	1973370	3.2
China	1380980	2.2
Vietnam	1128500	1.8
Mexico	1004710	1.6
Japan	2099000	3.4

Geopolymer Concrete (GPC) is a new class of concrete based on an inorganic alumino- silicate binder system compared to the hydrated calcium silicate binder system of concrete. It possesses the advantages of rapid strength gain, good mechanical and durability properties and is eco- friendly ansustainable alternative to Ordinary Portland Cement (OPC) based concrete. Geo-polymer materials represent an innovative technology that is generating huge amount of interest in the construction industry considering sustainable material. Although geopolymer concrete is a new technology but the use of this technology has started from the time of pyramids though that time it did not come in the front of the researchers like now to grasp their interest in it. Prof. J. Davidovits found that the polymerization process involves a substantially fast chemical reaction under alkaline condition on Si-Al minerals that result in 3D polymeric chain and ring structure consisting of Si-O-Al-O bonds. The main concept behind this geopolymer is the polymerization of the Si-O-Al-O bond which develops when Al-Si source materials like Fly ash or rice husk is mixed with alkaline activating solution (NaOH or KOH solution with Na2SiO3 or K2SiO3). The geopolymer can be in the form of -Si-O-Al-O - or –Si -O-Al -O-Si-O- or –Si-O -Al-O-SiO-Si-O-.

The geopolymer concrete mix was prepared as follows

NaOH (in water) + Na2SiO3 □Alkaline Liquid

Alkaline Liquid + Super plasticizer + Extra water + Aggregate + silica fume □Geopolymer Concrete

1.3 OBJECTIVE AND SCOPE:

The objective of this study is to assess the utility and efficacy of silica fume and alkaline liquids as a geopolymer concrete as an alternative to ordinary Portland cement concrete. The properties of materials have to be known before it can be used as an alternative of ordinary concrete. This study focuses on replacement of normal cement with silica fume as termed to be geopolymer concrete.If geopolymer concrete emerges successfully and attain the properties as normal concrete, it would be a milestone achievement for the local construction industries. Therefore, the main objective of this research is to determine the feasibility of pozzolanoic materials as in geopolymer concrete. The objectives of the study are briefly summarized below.

- To make a concrete without using cement (i.e. Geopolymer concrete
- To evaluate the optimum mix proportion of Geo-polymer concrete with fly ash replaced of cement and also the mix proportion of OPC.
- To study the different Strength properties of Geo-polymer concrete.

To make the study of the concrete this has been casted in different moulds and cured.

II. REVIEW OF LITERATURE

This Chapter presents a brief review of the terminology and chemistry of geopolymers, and past studies on geopolymers. Additional review of Geopolymer technology is available. Geopolymers are members of the family of inorganic polymers. The chemical composition of the geopolymer material is similar to natural zeolitic materials, but the microstructure is amorphous. The polymerization process involves a substantially fast chemical reaction under alkaline condition on Si-Al minerals, those results in a three-dimensional polymeric chain and ring structure consisting of Si-O-Al-O bonds (Davidovits, 1994).

The schematic Formation of Geopolymer Material

The schematic formation of geopolymer material can be shown as described by Equations (1) and (2)(Davidovits, 1994; van Jaarsveld et al., 1997).

Geopolymers include three classifications of inorganic polymers which depend on the ratio of Si/Al in their structures:

a) Poly (sialite) (-Si-O-AL-O-)

b) Poly (sialate-siloxo) (-Si-0-Al-0-Si-0-)

c)Poly (sialate-disiloxo) (-Si-0-Al-0-Si-0-Si-0-)

III. MATERIAL AND METHODOLOGY

3.*1* Ordinary Portland Cement

Cement used in the experimental work is Ordinary Portland Cement (OPC) of 53grade (ZUARI brand) conforming to IS: 12269-1987

3.2 Coarse aggregate

The coarse aggregate is obtained from a local quarry. The coarse aggregate with size less than 20mm and greater than 12.5 mm having a specific gravity 2.76 and fineness modulus of 7.36 is used in the present study. The rodded and loose bulk density values obtained are 1605 kg/m3 and 1477 kg/m3 respectively and the water absorption is 0.41%.

3.3 Fly-Ash

Fly ash, also known as flue-ash is one of the residues generated in combustion and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment

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before the flue gases reach the chimneys of coal-fired power plants and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide (CaO).

In the past, fly ash was generally released into the atmosphere but pollution control equipment mandated in recent decades now requires that it be captured prior to release. In the US, fly ash is generally stored at coal power plants or placed in landfills. About 43% is recycled, often used as a pozzolan to produce hydraulic cement or hydraulic plaster or a partial replacement for Portland cement in concrete production.

Fig-1: Fly-Ash

3.4 Methodology

The primary difference between geopolymer concrete and Portland cement concrete is the binder. The silicon and aluminum oxides in the low-calcium fly ash reacts with the alkaline liquid to form the geopolymer paste that binds the loose coarse aggregates fine aggregates and other un-reacted materials together to form the geopolymer concrete. As in the case of Portland cement concrete the coarse and fine aggregates occupy about 75 to 80% of the mass of geopolymer concrete. This component of geopolymer concrete mixtures can be designed using the tools currently available for Portland cement concrete. Mix design of geopolymer concrete is calculated from the density of geopolymer concrete. Generally, in the design of geopolymer concrete mix, coarse and fine aggregates have been taken as 75% of entire mix by mass. This value is similar to that used in OPC concrete in which they have been in the range of 75%to 80% of the concrete mix by mass. Fine aggregate has been taken as 30% of the total aggregate. The average density of geopolymer concrete has been considered similar to that of OPC concrete of 2400 kg/m3 based on literature survey. The combined mass offly ash and alkaline liquid arrived from the density of geopolymer concrete. From the combined mass, using ratio of fly ash to alkaline liquid the amount of fly ash and alkaline solution is determined. By taking the ratio of sodium silicate solution to sodium hydroxide solution, find out the mass of sodium silicate solution and sodium hydroxide solution is calculated by above procedure and issued for mix design.

Step-1*:* Making the Parameters Constant in Mix Design

Density of concrete 2400Kg/m3

Alkaline0liquid to fly ash ratio =0.35

Sodium Silicate to Sodium Hydroxide ratio=2.5
Molarity= 8 M Rest
Period = 1day

Admixture0Dosage = 3 %

Step 2. Calculation of Aggregates
Assume mass of coarse aggregate
[0.75- 0.8] Consider = 0.77

= 2400 * 0.77
= 1848 Kg/m3 (Aggregates = Coarse + Fine Aggregates)

Step 3. Calculation of fly ash And Alkaline Liquid Content

= 2400 – 1848

= 552 Kg/m3

Step 4. Calculation of values
Mass of fly ash = 552/(1+0.35) = 408.88 Kg/m3 mass of alkaline liquid = 552 – 408.88 = 143.11 Kg/m3

Step 5. Calculation of values of alkaline liquid

Mass of NaOH = 143.11/(1+2.5) = 40.8 Kg/m3
Sodium Hydroxide pilletswt for 8 Molarity is 26.2% of Sodium hydroxide solution i.e; 26.2/100X41= 10.74 kg/cum
And water in this solution is 41-10.74=30.26 kg /cum
Mass of Na_2SiO_3 = 143.11- 40.8 = 102.22 Kg/m3
Water to Fly Ash Ratio as =0.33
Water to geo polymer solids Ratio as =0.30
Commercial Available super0plasticizer is adopted as 1.5% of Fly ash by wt

Step 6. Calculation of mass of aggregates:

F.A = 35% of 1848
= 0.35 * 1848
=646.80 Kg/m3

C.A = 65 % of 1848
=0.65 * 1848

=1201 Kg/m3

Table-2: Mix Proportions of GPC

	Fly ash	F.A	C.A	Water	NaOH	Na_2Sio_3	Super plasticizer
Ratio	1	1.36	3.16	0.04	0.1	0.25	0.03

IV. RESULTS AND DISCUSSION

Table-3: Workability Values of Green Concrete (Geo Polymer Concrete) Mixes

S.No	Percentage of Metakaoline in Fly ash	Slump in mm
1	0%	40
2	2.5%	42
3	5%	45
4	7.5%	45
5	10%	45

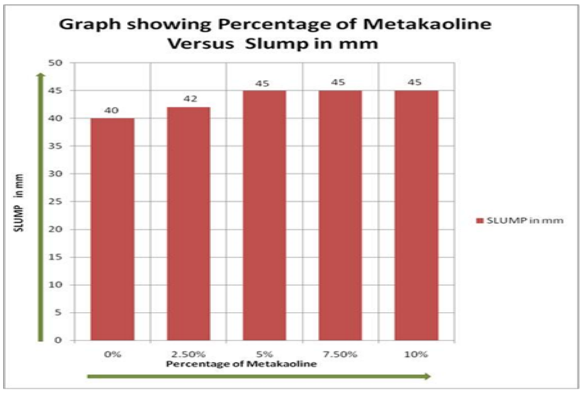

Fig.2: Slump of Geopolymer Concrete with Metakoline

4.1 Compressive0Strength:

Table-4: Compressive Strength with variation of Metakaoline percentage

S.No	Percentage of Metakaolin in Fly ash	Compressive Strength N/mm²
1	0%	17.6
2	2.5%	19.8
3	5%	22.6
4	7.5%	19.2
5	10%	18.7

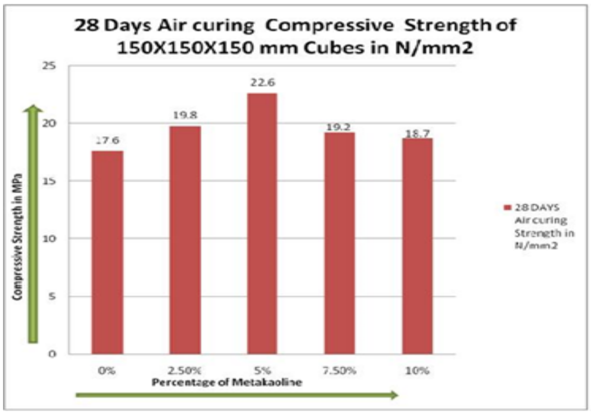

Fig.3: Compressive Strength of Geopolymer Concrete with Metakoline

4.2 Split Tensile Strength:

Table-4: Split tensile Strength with Metakaoline

S.No	Percentage of Metakaoline in Fly ash	Split tensile Strength N/Sqmm
1	0%	3.72
2	2.5%	4.18
3	5%	4.68
4	7.5%	4.07
5	10%	3.94

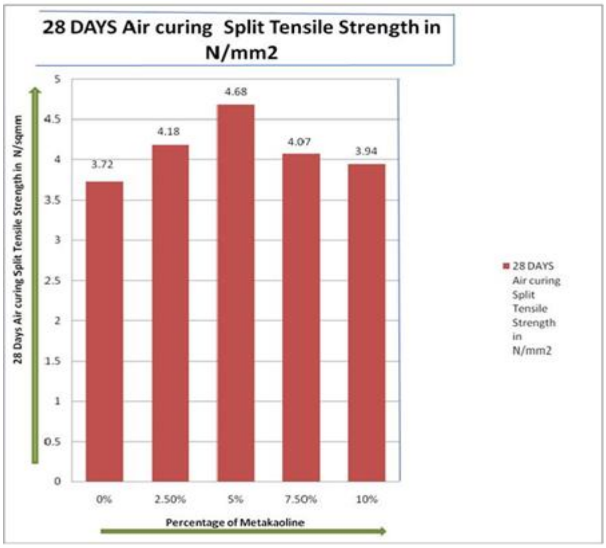

Fig.4: Split Tensile Strength of Geopolymer Concrete withMetakoline

4.3 Flexural Strength:

Table-5: Flexural Strength with variation of Metakaoline percentage

S.No	Percentage of Metakaolin in Fly ash	Flexural Strength N/Sqmm
1	0%	3.0
2	2.5%	3.2
3	5%	3.36
4	7.5%	3.25
5	10%	3.2

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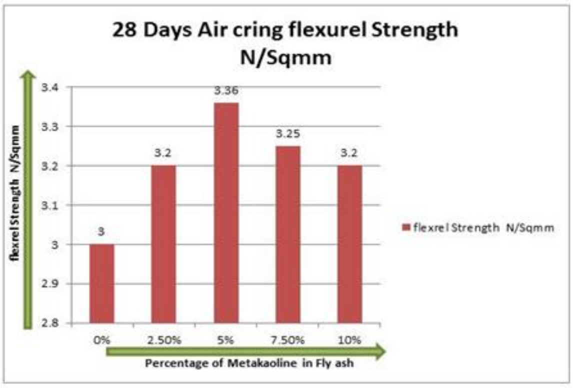

Fig.5:FlexuralStrength of Geopolymer Concrete with Metakoline

V. CONCLUSION

Based on the results obtained from this study, the following Conclusions seems to be valid.

- The increase in percentage replacement of Fly Ash with Metakaoline from 0% to 10.00% causes increase in Slump value up to 5% and beyond that slump is decreased.. This shows workability is reducing as percentage of Metakaoline increased beyond 5%. Hence, 5% replacement of Fly ash with Metakaoline is suitable from workability point of view.
- The increase in percentage replacement of Fly ash with Metakaoline from 0% to 5% causes increase in compressive strength of concrete from 17.6MPa to 22.6MPa. Further increase in percentage replacement of Fly ash with Metakaoline from 5% to 10% causes decrease in the compressive strength from 22.6MPa to 18.7MPa. Hence, 5.00% replacement of Fly Ash with Metakaoline is advisable from compressive strength point of view.
- The increasein percentage replacement of Fly ash with Metakaoline from 0% to 5% causes increase in Split Tensile strength of concrete from 3.72MPa to 4.68MPa. Further increase in percentage replacement of Fly ash with Metakaoline from 5% to 10% causes decrease in the split Tensile strength from 4.68MPa to 3.94MPa. Hence, 5.00% replacement of Fly Ash with Metakaoline is advisable from Split Tensile strength point of view.
- The increase in percentage replacement of Fly ash with Metakaoline from 0% to 5% causes increase in flexural Strength of concrete from 3.0MPa to 3.36 MPa. Further increase in percentage replacement of Fly ash with Metakaoline from 5% to 10% causes decrease in the flexural Strength from 3.36MPa to 3.2MPa. Hence, 5.00% replacement of Fly Ash with Metakaoline is advisable from flexural strength point of view. conclude Keeping in view
- Finally, it can conclude Keeping in view of the workability and compressive strength Split Tensile Strength and flexural Strength in mind, 5% replacement of Fly ash with Metakaoline is recommended for use in GEO POLYMER CONCRETE.

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I Mr.Naveen Kumar completed my M.tech in Structural engineering from MRIT college Affiliated to JNTU Hyderabad, secured 76.31%, B.Tech in Civil Engineering secured 74.74% from MRIT college Affiliated to JNTU Hyderabad. I have completed my Intermidiate from Royal junior college secured 86.6% and schooling from New Govt high school YMCA Secundrabad, Telangana secured 76.5%. Technical wise I have knowledge in Auto CAD, Staad.Pro.

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